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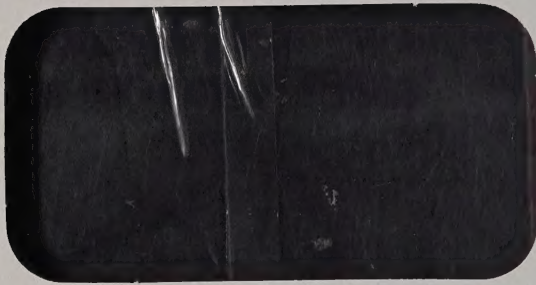
Model ABC 1000 (M)

Serial No. *E-67263*.....

INSTRUCTION MANUAL



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Model ABC 1000 (M)

Serial No. *E-6.7263*

INSTRUCTION MANUAL

The KEPCO equipment described in this instruction manual is of proprietary design, covered by one or more of the following United States patents and/or by other (U.S. and Foreign) Patents or patents pending.

2,992,379	3,112,439	3,241,042	3,275,948
2,992,386	3,128,423	3,243,690	3,303,411
3,028,538	3,131,344	3,243,749	3,303,412
3,056,905	3,210,619	3,275,925	3,303,415
3,088,053	3,226,628	3,275,927	3,305,763
3,092,757	3,241,054		

Canadian Patents: 733629 – 736084

Australian Patents: 263,835 – 264,975

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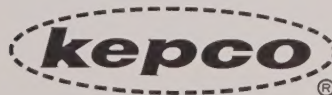


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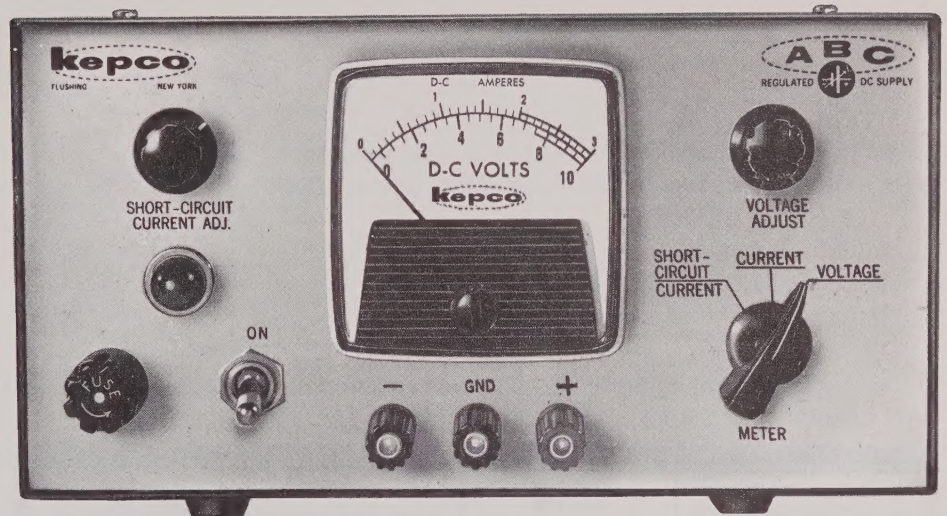
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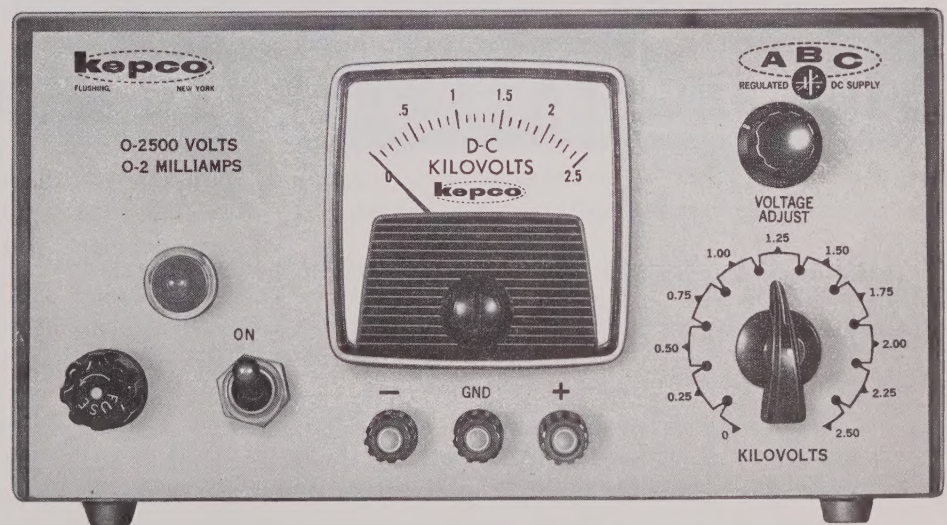
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a) MODELS ABC 200 AND ABC 425



b) MODELS ABC 1000, ABC 1500 AND ABC 2500

FIG. 1-1 ABC-HYBRID POWER SUPPLY, FRONT VIEW

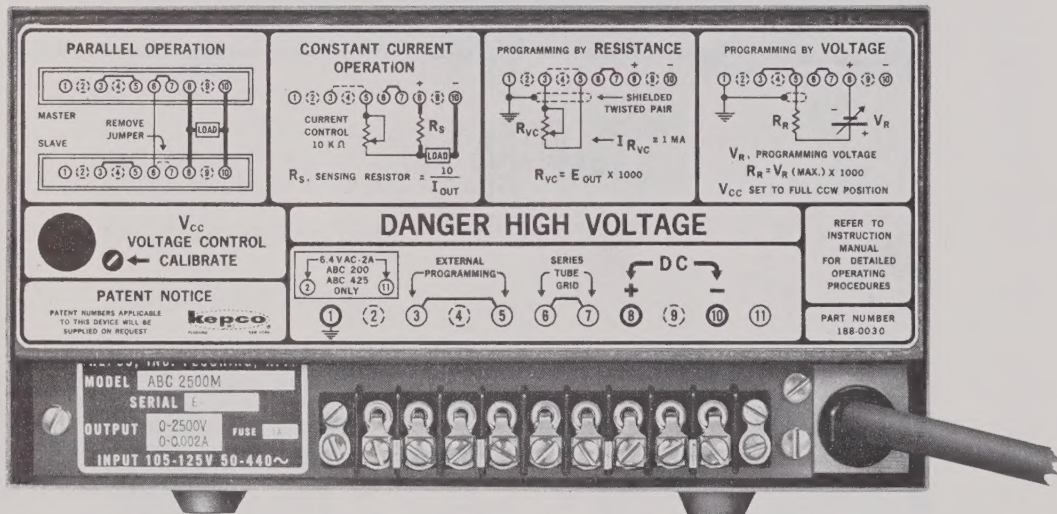


FIG. 1-2 ABC-HYBRID POWER SUPPLY, (TYPICAL) REAR VIEW

SECTION I - INTRODUCTION

1-1 SCOPE OF MANUAL

1-2 This manual contains instructions for the installation, operation and maintenance of the ABC-HYBRID power supply group, manufactured by Kepco Inc., Flushing N.Y.

1-3 DESCRIPTION

1-4 The Kepco ABC-HYBRID power supplies are general purpose, highly regulated DC power supplies suited for rack-mounting or bench use. All models in the ABC-HYBRID group are similar in design, featuring vacuum tubes as the series-control or pass-element, with solid state error-signal amplifier and reference circuits. The major differences between the ABC-HYBRID models consist in their individual output ranges (Refer to Table 1-1) and their method of voltage control. While Models ABC 200 and ABC 425 have continuous voltage control by means of a ten-turn rheostat over their full range, Models ABC 1000, ABC 1500 and ABC 2500 are, in addition, equipped with a ten position step switch. The ten-turn rheostat in these models serves as a fine control, interpolating between switch positions and providing high resolution of the output voltage control.

1-5 PROGRAMMING. Rear barrier-strip terminals on all ABC-HYBRID models provide for remote resistance programming of output voltage or current at 1000 ohms per volt. Additional terminals serve for programming connections by external voltage,* the operation of the power supply as a constant current source and other applications (Refer to Section III, Operating Procedures).

*Note: The Model ABC 2500 can be voltage programmed from approximately 850 to 2500 V only. Resistance programming is possible through the entire range.

1-6 CURRENT LIMITING. Current limiting circuitry permits continuous operation into a short circuit on all ABC-HYBRID models. The output returns automatically to the operating voltage when the overload is removed. Fixed current limiting at about 150% of rated maximum output current is provided with Models ABC 1000, ABC 1500 and ABC 2500. Variable current limiting from 25% to 150% of rated maximum output current is featured on Models ABC 200 and ABC 425.

1-7 MECHANICAL. The chassis and supporting frame of the ABC-HYBRID power supplies is constructed of cold rolled, cadmium plated steel. The front panel is made of aluminum, etched and coated. The case is perforated steel, plated and painted.

MODEL	DC OUTPUT RANGE		RIPPLE RMS MV	OUTPUT IMPEDANCE OHMS MAX.			MAX. INPUT AMPS At 125 V AC
	VOLTS	MA.		DC to 100 CPS	100 CPS to 1 KC	1 KC to 100 KC + μ H	
ABC 200M	0-200	0-100	0.5	1	0.5	2.0+2.0	0.5
ABC 425M	0-425	0-50	0.5	4	0.5	2.0+2.0	0.5
ABC 1000M	0-1000	0-20	1.0	25	1.0	2.0+10.0	0.5
ABC 1500M	0-1500	0-10	1.0	75	1.0	2.0+10.0	0.3
ABC 2500M	0-2500	0-2	1.0	625	1.0	2.0+10.0	0.3

TABLE 1-1, SPECIFICATIONS ABC-HYBRID POWER SUPPLIES

1-8 SPECIFICATIONS, GENERAL

- a) INPUT REQUIREMENTS: 105 to 125 V AC or 210 to 250 V AC, 50 to 440 Hz, single phase. Refer to Table 1-1 for AC input current.
- b) AMBIENT OPERATING TEMPERATURE: -20°C to +55°C maximum.
- c) STORAGE TEMPERATURE: -40°C to +85°C maximum.
- d) ISOLATION VOLTAGE: A maximum of 1000 volts (DC or P-P) can be connected between the chassis and either output terminal.
- e) AUXILIARY OUTPUT: (Models ABC 200 and ABC 425 only) 6.5 V AC, unregulated, maximum 2 amperes at the rear barrier strip.

1-9 SPECIFICATIONS, VOLTAGE REGULATION MODE.

- a) REGULATION:
 - 1) Line: Less than 0.05% or 5 mV whichever is greater, output voltage change, for 105 to 125 V AC or 210 to 250 V AC line variation, at any output voltage within the specified range.
 - 2) Load: Less than 0.05% or 5 mV whichever is greater, output voltage change, for "no load" to "full load" change at any output voltage within the specified range.
- b) STABILITY: Less than 0.05% or 50 mV whichever is greater, output voltage change, over a period of 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.

- c) TEMPERATURE COEFFICIENT: Less than 0.05% per °C output voltage change.
- d) RIPPLE: Refer to Table 1-1 for specifications applicable for individual model.
- e) RECOVERY TIME: 50 microseconds.
- f) OUTPUT IMPEDANCE: Refer to Table 1-1 for specifications applicable for individual model.
- g) OVERSHOOT: No output voltage overshoot from turn-on, turn-off or power failure for output settings above 25% of the maximum rated output voltage. Below 25%, output overshoot is a function of load current and is negligible for load currents in excess of 10% of the maximum rated output current of the power supply.

1-10 SPECIFICATIONS, CURRENT REGULATION MODE (EXTERNAL SENSING)

Note: This specification is valid only when the selected external sensing resistor and current control resistors are high-quality, wire wound units with temperature coefficients of twenty parts per million or better.

- a) OUTPUT RANGE: Current regulation from 1 mA to 100% of the maximum rated output current.
- b) COMPLIANCE: Voltage compliance range is zero to 100% of maximum rated output voltage. For any selected output current range, the output voltage is automatically varied throughout the compliance range as required to regulate the output current.
- c) REGULATION
 - 1) Line: Less than 0.1% output current change for 105 to 125 V AC line variations, if the specified* voltage sample is maintained across the external sensing resistor.
 - 2) Load: Less than 0.1% output current change for the maximum change in load resistance, if the specified* voltage sample is maintained across the external sensing resistor.

*The external sensing resistor is chosen to produce a 10 volt drop at the maximum operating current.

- d) STABILITY: Less than 0.1% or 10 μ A output current change, whichever is greater, over a period of 8 hours after warm-up. Measured at constant line voltage, load and ambient temperature.
- e) TEMPERATURE COEFFICIENT: Less than 0.1% output current change per °C.
- f) RIPPLE: Less than 0.1% of maximum output current, rms.

1-11 SPECIFICATIONS, PHYSICAL

- a) METERS: ABC-HYBRID power supplies suffixed "M", include 2 1/2" meter, 2% full scale accuracy. Models ABC 200M and ABC 425M have a combination voltmeter/ammeter in combination with a meter selector switch at the front panel. Models ABC 1000M, ABC 1500M and ABC 2500M have a voltmeter only.
- b) TERMINATIONS AND CONTROLS: Refer to Section II, FIG.'s 2-1 and 2-2 for the location and function of all front and rear terminations and controls.
- c) DIMENSIONS: Refer to mechanical outline drawing (FIG. 1-3 for dimensions.
- d) STANDARD FINISH:
 - 1) Panel: Etched Aluminum, brushed and coated.
 - 2) Case: Gray Hammertone.

1-12 ACCESSORIES

- a) RACK MOUNTING ADAPTORS: (5 1/4" high x 19" wide)
 - 1) Kepco Model RA-5 (single unit mounting)
 - 2) Kepco Model RA-4 (two unit, side by side mounting)

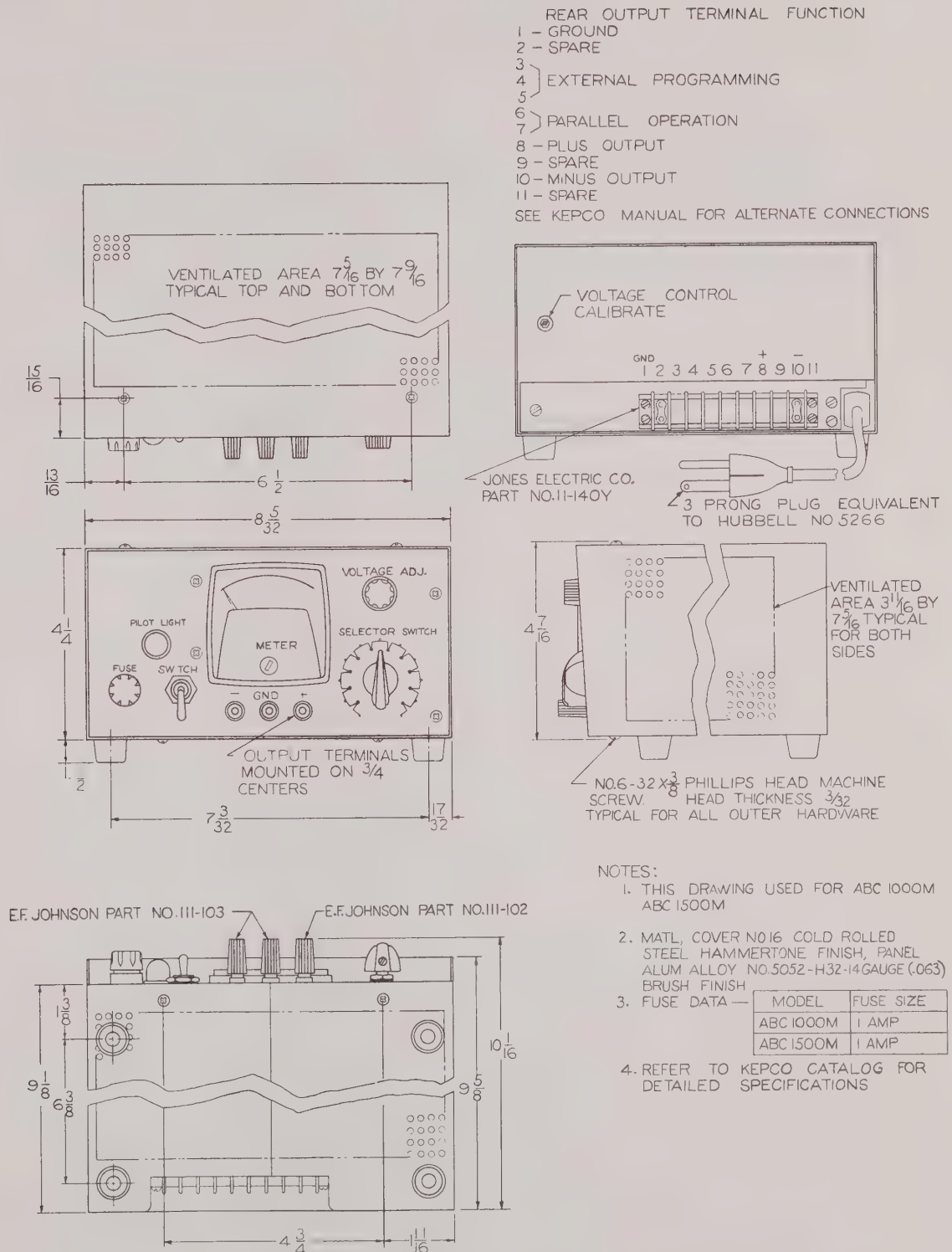


FIG. 1-3 MECHANICAL OUTLINE

SECTION II - INSTALLATION

2-1 UNPACKING AND INSPECTION

2-2 This power supply has been inspected and tested at the factory prior to packing and is shipped ready for operation. After careful unpacking, inspect the instrument for shipping damage before attempting to operate it. Perform the operational check as described in Paragraph 2-13 below. If there is evidence of shipping damage, file a claim immediately with the responsible transport service.

2-3 TERMINATIONS

a) FRONT PANEL: Refer to FIG. 2-1 and Table 2-1.

b) REAR: Refer to FIG. 2-2 and Table 2-2.

2-4 AC POWER REQUIREMENTS

2-5 This power supply is normally shipped for operation on a single phase, 115 V AC line. If 230 V AC operation is desired, the transformer primary link connections must be changed as described below.

2-6 PROCEDURE FOR 230 V CONVERSION (Refer to FIG. 2-3 A and B)

a) Disconnect unit from power line and remove from case by removing the five (5) holding screws and sliding the case back until the transformer terminals are visible.

b) Remove jumpers between terminals (1)-(2) and (3)-(4).

c) Place wire jumper between terminals (2) and (3) as shown and solder in place.

d) Replace 1A fuse by 0.5 A, "Slow Blow" type.

e) Replace case and secure with holding screws.

2-7 GROUNDING

2-8 For safety reasons, it is imperative that the metal chassis of the power supply will be always kept at ground potential. If the safety line cord and three prong plug are used in connection with a properly

grounded outlet, this will be done automatically. However, if an adaptor is used for a non-grounded outlet, the chassis must be grounded separately.

2-9 ISOLATION

2-10 The DC output terminals of the ABC power supply are isolated from the chassis and from the power line, except for a capacitive connection from the positive output to chassis. Either side of the supply may be grounded, or a maximum of 500 V DC (plus the supply voltage) can be connected between chassis or either output terminal.

2-11 COOLING

2-12 This power supply is designed to have sufficient convection cooling through its perforated, wrap-around case. Allow sufficient space around the unit to allow free air circulation. If the instrument must be mounted into confined space, forced air cooling may be necessary to keep the surrounding temperature within the ambient temperature rating of the ABC power supply.

2-13 OPERATIONAL CHECK

2-14 BEFORE TURN-ON. Check all terminal screws at the rear barrier strip. All jumper links and terminal screws must be tight for proper functioning of the power supply.

2-15 TURN-ON (Refer to FIG. 2-1)

- a) Rotate "Voltage Control" clockwise, approximately two turns from its maximum counter clockwise position. Set range "Selector Switch" to lowest range if unit is so equipped. Connect voltmeter of suitable range to either front or rear output terminals.
- b) Connect power supply to the line and turn power switch "on". Approximately 30 seconds are required after turn-on for the series regulator tube filaments to warm-up before regulated output voltage is available.
- c) Turn "Short Circuit Current Adjust" to its maximum clockwise position. (If unit is so equipped.)

- d) Turn "Voltage Control" slowly clockwise and then counter clockwise. Observe panel meter (or external voltmeter) for a smooth increase or decrease of the output voltage. When the "Voltage Control" is turned fully clockwise, the output voltage should equal or slightly exceed the maximum voltage rating of the power supply, or in case of units equipped with multi-range switch, it should equal the maximum range voltage. When the control is fully counter clockwise, the output voltage should be zero or slightly negative. (Only on first range on multi-range units)
- e) On multi-range units, turn range switch to the next range and repeat (d) until all ranges up to the maximum output voltage of the unit are tested. The "Voltage Control" serves as a fine control within each range. Continuous covering from zero to full output voltage should be present since all ranges "overlapp" each other.

2-16 DC OUTPUT CONNECTIONS: The load may be connected at the binding post terminals at the front of the unit, or at rear terminals, (4) and (6). Specified regulation applies to the rear terminals only and is measured as described in Section V.

2-17 OVERLOAD PROTECTION

2-18 MODELS ABC 200 and ABC 425. The "Short Circuit Current Adjust" control on the front panel may be adjusted over a range from approximately 25% to 150% of the rated maximum output current of the power supply. The control should be set to at least 150% of the load current at which the supply is to be operated. To facilitate this setting, the ABC power supply is equipped with a meter function switch (FIG. 2-1), which applies (in its maximum counter clockwise position) a short circuit across the supply. The resulting short circuit current may be read directly on the panel meter or, on unmetered units, on an external ammeter across the output terminals. Simultaneously, the "Short Circuit Current Adjust" on the front panel may be adjusted to the desired load current, plus 50%. If, for example, 80 mA of load current are required, the short circuit current should be adjusted to at least 120 mA.

2-19 If lower settings of current limits are not specifically required, it is recommended that the "Short Circuit Current Adjust" control be set to its maximum clockwise position. At this setting, the output can be operated at any current up to its rated maximum. Overload protection will still be given at 150% of the rated maximum output current.

2-20 MODELS ABC 1000, ABC 1500, ABC 2500. These models have short circuit current adjustments (internal) factory-set to 150% of their maximum output current. These controls do not need re-adjustment unless they or their associated circuit components must be replaced. The procedure for re-adjustment is given in paragraph 5-3.

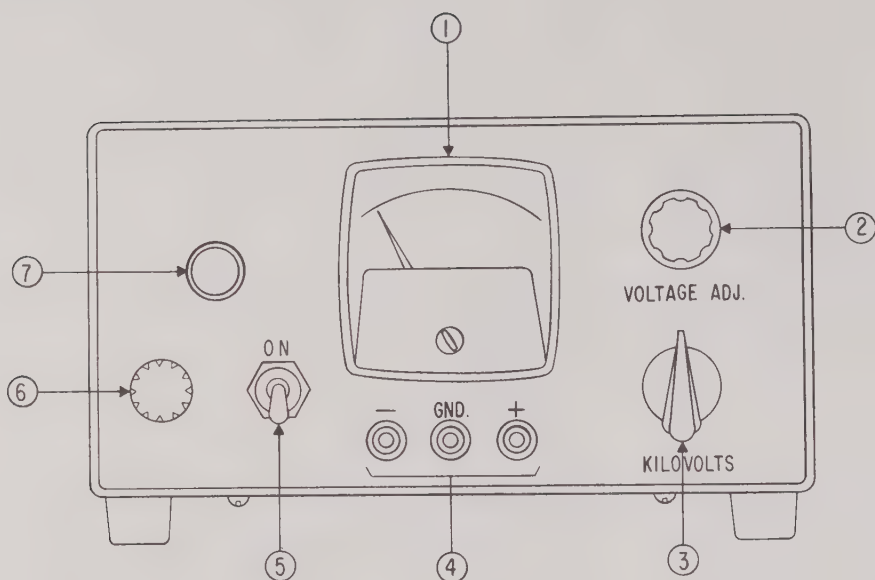


FIG. 2-1 TERMINALS AND CONTROLS, FRONT

NO.	TERMINAL OR CONTROL	FUNCTION
1*	METER	MEASURES OUTPUT VOLTAGE.
2	VOLTAGE CONTROL (FINE)	TEN-TURN POTENTIOMETER SETS OUTPUT VOLTAGE BETWEEN STEPS OF THE COARSE CONTROL.
3	VOLTAGE CONTROL (COARSE)	10 POSITION STEP SWITCH. SETS OUTPUT VOLTAGE IN TEN EQUAL STEPS.
4	OUTPUT TERMINALS	LOAD CONNECTION AND GROUND TERMINAL.
5	ON-OFF SWITCH	URNS LINE POWER "ON" OR "OFF".
6	FUSE	PROTECTS POWER TRANSFORMER.
7	PILOT LIGHT	INDICATES LINE POWER "ON" OR "OFF."

*METERED UNITS ONLY.

TABLE 2-1 TERMINALS AND CONTROLS, FRONT

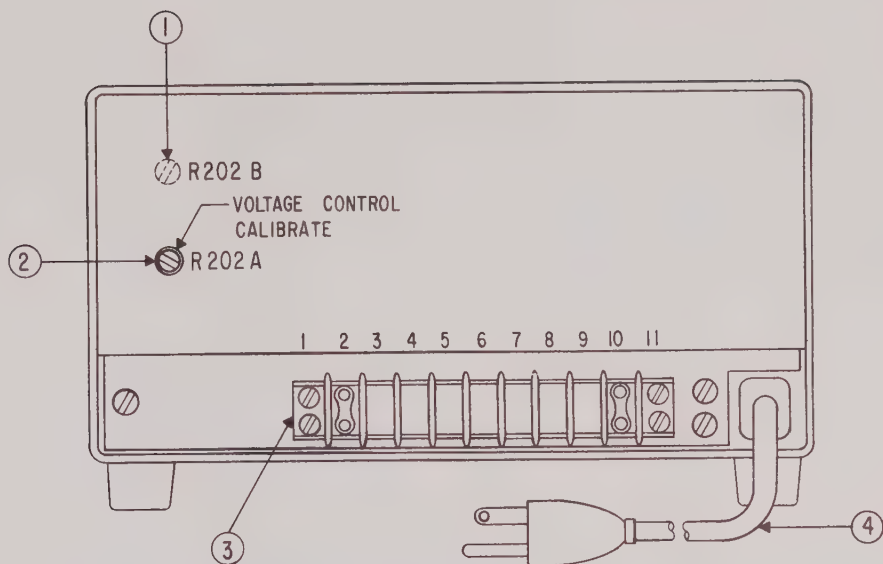


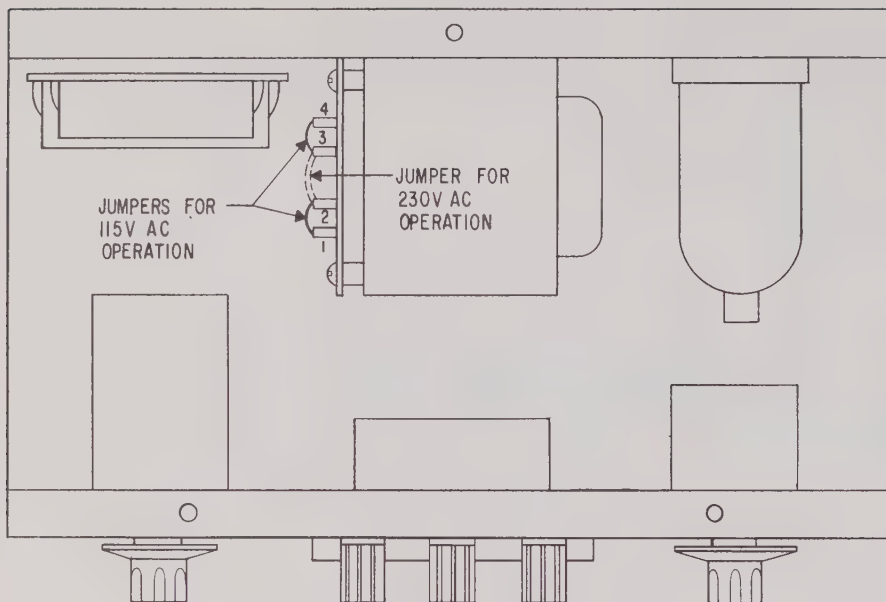
FIG. 2-2 TERMINALS AND CONTROLS, REAR

NO.	TERMINAL OR CONTROL	FUNCTION
1	CURRENT LIMIT ADJUST	ADJUSTS UPPER-LIMIT OF SHORT-CIRCUIT CURRENT. (ACCESSIBLE AFTER CASE REMOVAL).
2	VOLTAGE CONTROL CALIBRATION	ADJUSTS MAXIMUM OUTPUT VOLTAGE (I_b ADJUST). (CALIBRATE CONTROL)
3	REAR BARRIER STRIP	OUTPUT AND PROGRAMMING TERMINALS. (REFER TO SECTION III FOR DETAILS)
4	LINE CORD	CONNECTS SUPPLY TO A.C. POWER LINE.

TABLE 2-2 TERMINALS AND CONTROLS, REAR

A) MODELS: ABC200
ABC425
ABC1000
ABC1500

BOTTOM VIEW



B) MODEL : ABC 2500

TOP VIEW

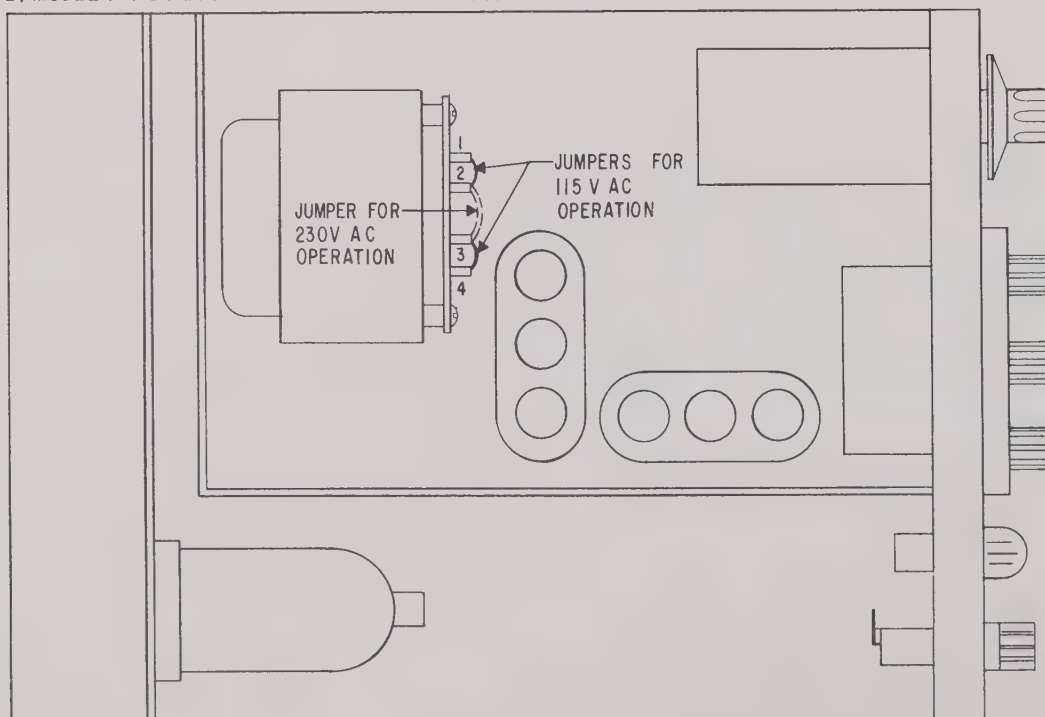


FIG. 2-3 CONVERSION TO 230V AC LINE VCLTAGE OPERATION, ABC-HYBRID GROUP

SECTION III - OPERATING PROCEDURES

3-1 STANDARD OPERATION

3-2 TURN-ON. The Kepco ABC-HYBRID DESIGN GROUP makes use of vacuum tubes for the series regulator stage in the power supply. A short waiting period (approximately 30 seconds) is therefore required after turn-on for the filaments in the tubes to come to full operating temperature and for the regulated voltage to be available at the output.

3-3 JUMPER LINKS. The ABC-HYBRID power supply is shipped with jumper links in place on the rear barrier strip (TB201) between terminals (3)-(4)-(5) and terminals (6)-(7). These links must all be in their proper place and tightened securely for standard operation. Loose jumper links or loose wire connections on the rear barrier terminals will cause malfunction of the power supply.

3-4 LOAD CONNECTION. The load may be connected to the output terminals on the rear barrier strip, [terminals (8) positive and (10) negative] or at the front panel output terminals.

3-5 VOLTAGE CONTROL (MODELS ABC 1000, ABC 1500 and ABC 2500)

Voltage control on ABC-HYBRID power supplies with an output voltage of 1000 volt and higher is performed with two front panel controls: a ten-position range switch, serving as the "coarse" control, and a ten-turn potentiometer for "fine" control within the individual ranges. The ten-position range switch divides the maximum output voltage of the individual model into ten equal voltage steps and is calibrated in increments of 10% of the maximum output voltage. The continuously variable ten-turn fine control sets the output voltage to the desired value within the range selected by the range switch. Sufficient "overlap" of each range insures continuous coverage of the full output voltage band.

3-6 VOLTAGE CONTROL (MODELS ABC 200 and ABC 425)

ABC-HYBRID power supplies below 1000 volt output voltage are provided with a continuous control over their full output range. The ten-turn voltage control may be set to any position at turn-off or turn-on of the power supply.

3-7 SHORT CIRCUIT CURRENT ADJUST (MODELS ABC 200 and ABC 425)

While ABC-HYBRID power supplies with output voltages of 1000 volts and above have fixed short circuit protection, which is set to approximately

150% of their rated maximum output current, Models ABC 200 and ABC 425 are equipped with front panel controls which permit the adjustment of the short-circuit current in the range from approximately 25% to 150% of their rated maximum output current. This control should be set to approximately one third higher than the actual operating current required, since current limiting action begins when the output current reaches $\approx 75\%$ of the value to which this control is set. (Refer to FIG. 3-1)

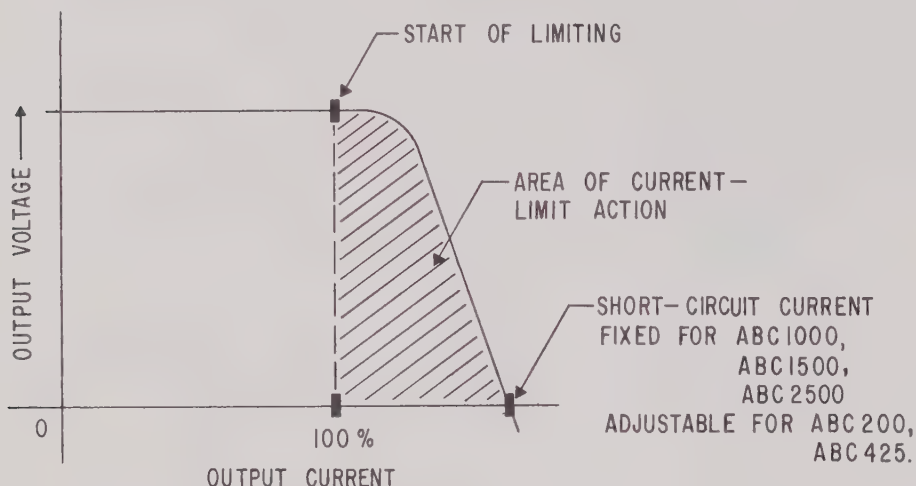


FIG. 3-1 CURRENT LIMITING CHARACTERISTIC, ABC-HYBRID POWER SUPPLIES

- 3-8 Operation of the power supply in the area of current limiting (see FIG. 3-1) will degrade power supply performance. When lower settings of the short circuit current are not essential, the SHORT CIRCUIT ADJUST control should be left at its maximum clockwise position. At this setting, the power supply can be operated at any current up to its rated maximum, without going into current limiting. Overload protection will still be present for current exceeding the maximum rated output current of the power supply.
- 3-9 Adjustment of the SHORT CIRCUIT CURRENT ADJUST control is performed while actually shorting the power supply and reading the short circuit current on an ammeter. This adjustment is simplified on metered units, which have a special meter selector switch. One position of the switch is a momentary "short circuit current position," allowing the user to hold the switch in this position, while reading the short circuit current directly on the panel meter and adjusting its value with the front panel control. On unmetered units, the supply must be shorted with a suitable ammeter directly across the output. Then the panel adjustment can be made and the power supply is ready for operation.

3-10 INTRODUCTION TO PROGRAMMING

3-11 GENERAL. The output voltage of the ABC-HYBRID power supplies may be remotely controlled (programmed) by either external resistance or unipolar voltages. By the use of external sensing-and control resistors, these normally voltage regulated supplies can be converted to provide constant current. In order to familiarize the user of this equipment with the various modes of operation described in the following paragraphs, the basic relationships governing the operation of the Kepco Comparison Bridge (See FIG. 3-2) are derived and should be kept in mind.

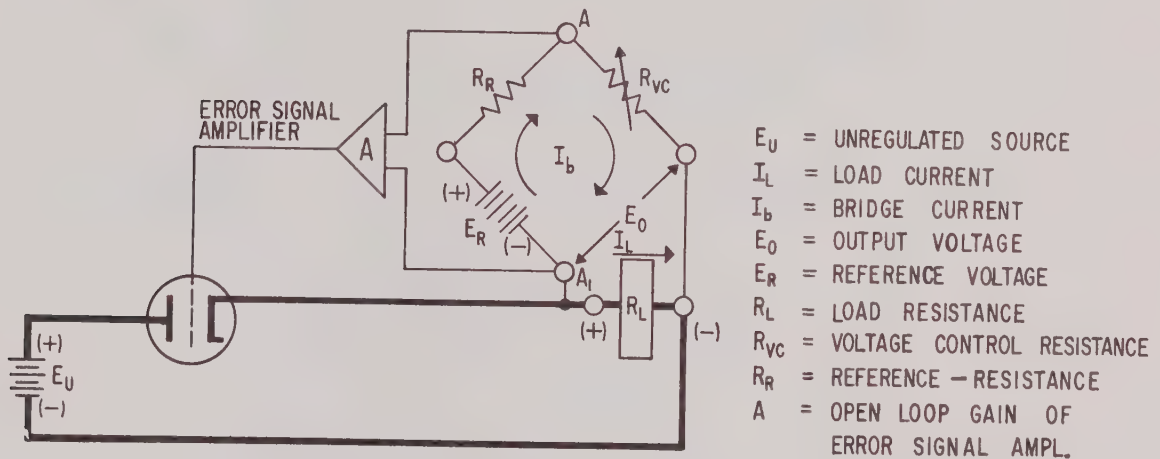


FIG. 3-2 KEPKO COMPARISON BRIDGE (SIMPLIFIED)

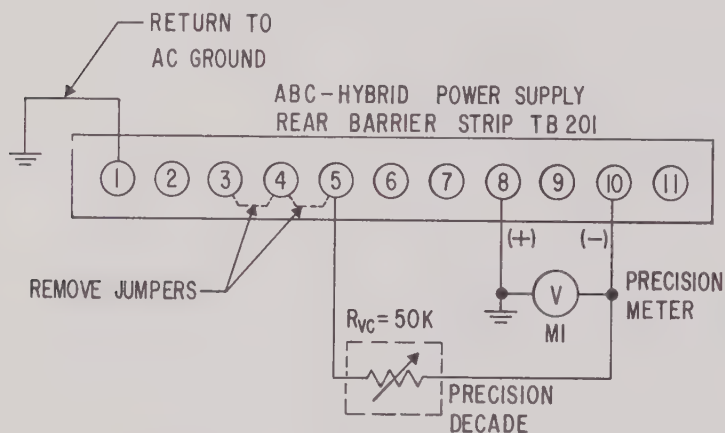
3-12 COMPARISON BRIDGE CIRCUIT ANALYSIS. The bridge consists of four arms, with the error-signal amplifier connected to the "null" points (A,A'). At balance ($E_{AA'} = 0$) it is seen that: $\frac{E_R}{R_R} = \frac{E_O}{R_{VC}}$ (Eq. 1)

The bridge current (I_b) is generated by E_R/R_R , so that $I_b = \frac{E_R}{R_R}$ (Eq. 2).

Substituting (Eq. 2) into (Eq. 1) we get $E_O = I_b R_{VC}$ (Eq. 3). The error signal amplifier, the power source and the pass element constitute an inverting power amplifier which tends to regulate in such a way, that equations (1), (2) and (3) are always true. These basic equations in combination with the simplified bridge circuit schematic (FIG. 3-2) should assist the user in the set-up of the various programming circuits described below.

3-13 ADJUSTMENT FOR EXACT PROGRAMMING RATIO

3-14 Referring to (Eq. 3): $E_o = I_b R_{vc}$, it is seen that if $I_b = 1 \text{ mA}$ as in all ABC-HYBRID power supplies, 1000 ohms of control resistance (R_{vc}) is needed for every volt of output. The "Programming Ratio" of 1000 ohms per volt is therefore based on the bridge current I_b . This bridge current is adjustable $\pm 5\%$ around the nominal value and is set slightly higher in the ABC power supplies to insure full output voltage coverage with the built-in voltage controls. Before remote programming with precision resistors, I_b can be calibrated to insure accurate results.



NOTE:
ADJUST R202A FOR
EXACTLY 50.0 V

FIG. 3-3 CONNECTIONS FOR PRECISION PROGRAMMING RATIO ADJUSTMENT

3-15 PROCEDURE (Refer to FIG. 3-3)

a) EQUIPMENT REQUIRED:

- 1) Precision digital or differential voltmeter (M-1).
- 2) Precision resistor, 0.1% accuracy or better (R_{vc}). The value is not critical, but must be known precisely. For every 1000 Ω , 1 volt output will be read-out on the meter.

b) With line power removed from the power supply, remove links between terminals (3)-(4)-(5) on the rear barrier strip (TB201).

c) Connect external components as shown in FIG. 3-3.

d) Turn line power "on". If the external resistor has a value of 50 K ohms for example, approximately 50 volts will appear at the output.

- e) Adjust R202A ("Voltage Calibrate Control") for precisely 50 volts as read-out on M-1. The programming ratio of 1000 ohms per volt is now adjusted.

3-16 RESISTANCE PROGRAMMING

3-17 GENERAL. The output voltage of the ABC-HYBRID power supply may be controlled or programmed over its full range (or if desired, over any part of its output voltage range) at the nominal programming ratio of approximately 1000 ohms per volt. (Refer to paragraph 3-13, if precision ratio adjustment is required.) In this mode of operation, the internal voltage control is disconnected and an external or remote voltage control is substituted. This new control resistance may take the form of a precision decade, fixed and step-switch controlled resistors or motor driven potentiometers.

3-18 PRECAUTIONS. Certain precautions must be taken in all programming operations to insure the safety of the operator as well as that of the equipment:

- a) CAUTION - HIGH VOLTAGE. Maximum output voltage will appear across the terminals of the external programming resistors. The resistor(s) must have a voltage break-down rating in excess of the maximum rated output voltage of the power supply. All exposed terminals should be well insulated. The shielded wire must have the proper voltage rating. (Ordinary shielded wire is only rated for a maximum of approximately 500 V.
- b) All resistors used for external programming must be high quality, wire-wound units with temperature coefficient in the order of 20 parts per million. Step-switches or relays must have contacts of the "make before break" variety.
- c) The quiescent DC current through the programming resistor is the bridge current (I_b) of 1 mA. However, when large voltage excursions are programmed an error current much larger than the steady state bridge current flows. Its magnitude equals the amplitude of the voltage step, divided by the resistance of the voltage control after the programming step, and its time constant equals the charge or discharge time of the output filter capacitor. Large peak currents may therefore result if the voltage control is set close to zero ohms. In applications where large voltage steps down to zero volts are required, the programming resistors must be rugged wire-wound units of a power rating several times that of the actual dissipation under quiescent DC conditions.

- d) In vernier control applications, where the internal voltage control (R_{VC}) is connected, limiting resistors in series with R_{VC} must be used when programming close to zero volts. These limiting resistors are built-in for ABC-HYBRID power supplies on models from 1000 volt output voltage and above, but not on Models ABC 200 and ABC 425. If programming to absolute zero volts is essential, vernier control can not be used and all programming or voltage control resistors must be connected externally. (See paragraph 3-19C)

3-20 The two following examples should illustrate the previous paragraphs and resistance programming in general:

- a) EXAMPLE I. A Kepco Model ABC 1500 is to be resistance programmed in the range from zero to 1000 volts. Equal steps of 100 V each are desired.

PROCEDURE:

- 1) Adjust the programming ratio as described in paragraph 3-13. Since we need 1000 Ω for each volt output, the total resistance needed is 1 Megohm. The total quiescent power dissipation is 1000 V x 1 mA = 1 watt. We select 10 resistors, 100 K ohms, wire-wound, 10 watt each.

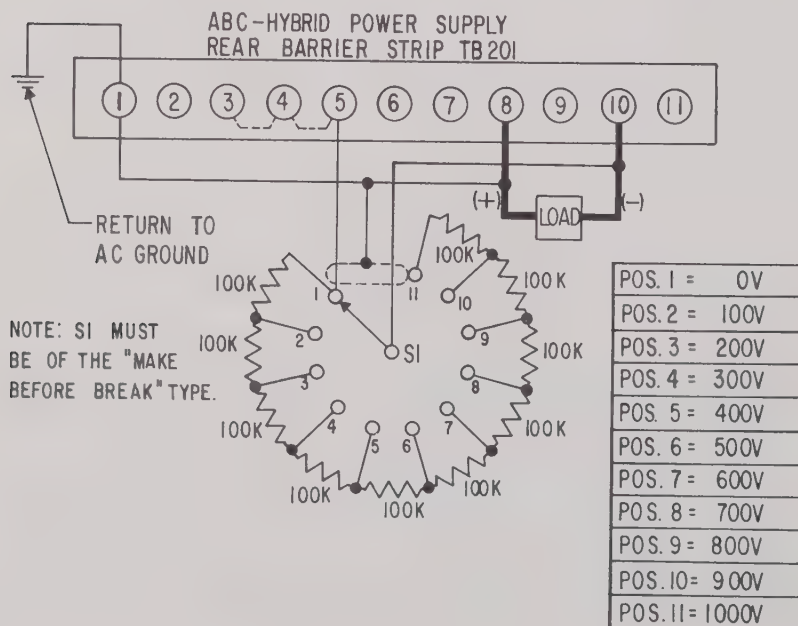


FIG. 3-4 FULL RANGE RESISTANCE PROGRAMMING

(Procedure con't.)

- 2) Remove links on rear barrier strip terminals (3)-(4)-(5). This disconnects the internal voltage control from the circuit. These links must be replaced and secured tightly when returning to normal operation.
 - 3) Connect components as shown in FIG. 3-4. The switch may be a relay or similar device. The switching speed is limited only by the response time of the power supply which in turn is given by the charge and discharge time of the output capacitor.
 - 4) The step switch arrangement shown may be replaced by any other arrangement of resistors or rheostats (always in the ratio of 1000 ohms per 1 volt output) as long as the precautionary notes given in paragraph 3-19 are kept in mind.
- b) EXAMPLE II. A Kepco Model ABC 200 is to be vernier controlled over its full range. The vernier range shall be ± 1 volt. A protective resistor will be used to limit the error current in the vernier, but should not itself program more than 1.0 V DC.

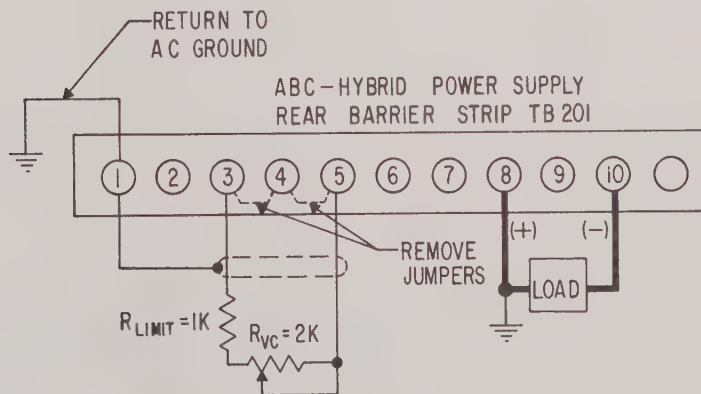


FIG. 3-5 RESISTANCE PROGRAMMING, VERNIER CONTROL

PROCEDURE:

- 1) Since resolution, not accuracy is the criterion in this application, the programming ratio does not have to be precision adjusted. For a ± 1 volt vernier range we need a 2 Kilohm rheostat which can be single turn or multi-turn, depending on the desired resolution. Power dissipation is very small, since the quiescent conditions are 2 volts and 1 milliampere, so that a 1/2 watt, wire-wound potentiometer wired as a rheostat is ample. A zero limiting resistor

should be selected to protect the vernier from excess error current. A 1 K Ω , wire-wound, 1 watt resistor will be sufficient. This resistor will limit the minimum output to 1 volt.

- 2) Remove links on rear barrier strip terminals (3)-(4)-(5). These links disconnect the internal voltage control from the circuit and must be carefully replaced and tightened when returning to normal operation.
- 3) Connect components as shown in FIG. 3-5. The power supply voltage may now be set with the panel control to any desired voltage within the range and can be fine controlled ± 1 volt around the pre-set value with the external vernier control.

3-21 PROGRAMMING OUTPUT VOLTAGE WITH EXTERNAL VOLTAGE

3-22 The output voltage of the KEPCO ABC-HYBRID Power Supply can be controlled by an external, variable voltage source which replaces the fixed, built-in reference source. This mode of operation is referred to as "Voltage Programming". It can be mathematically expressed by referring to basic equation (1):

$$\frac{E_r}{R_r} = \frac{E_o}{R_{vc}} \quad . \quad \text{Solving for } E_o, E_o = -E_r \times \frac{R_{vc}}{R_r} \quad .$$

Denoting the variable programming source E_i and substituting for E_r we have:

$$E_o = -E_i \frac{R_{vc}}{R_r} \quad (\text{equation 4})$$

Consequently, if E_i is varied in this expression and the ratio $\frac{R_{vc}}{R_r}$,

which represents the closed loop gain of the system, is held constant, the output voltage E_o will vary linearly with E_i . Referring back to equation (4) we see that the expression is similar to the inverted amplifier equation for an operational amplifier. The voltage programmed power supply does in fact become a unipolar power amplifier with potentially very high power gain but with limited frequency response. (Refer to FIG. 3-6). The limited frequency response is largely due to the effect of the output capacitor C_o acting as a low-pass filter and preventing the output voltage (E_o) from varying rapidly. High speed models are available which have no output capacitor and can program at 500,000 volts per second. These models contain special circuitry to compensate the amplifier for stability.

ATTENTION The Kepco Model ABC 2500 is programmed by external voltage using a minimum control current of 0.3 mA. Since the control current times the voltage control resistance determines the output voltage ($E_o = I_b R_{vc}$, eq. 3), E_o is

restricted on this model to a value given by $(0.3 \text{ mA}) \times (R_{VC})$.
For example if the built-in voltage control is used for R_{VC}
and its setting is fully clockwise (2.5 megohm) the output
range is 750 to 2500 V DC, while I_b varies from 0.3 to 1 mA.

3-23 A practical example to illustrate the method of voltage programming
will be given below:

EXAMPLE: A Kepco ABC 1000 power supply is to be programmed over its
full range from a variable, unipolar source, with a peak
output voltage of 20 volts and capable of delivering 1 mA
of stable current. The internal voltage control and there-
fore the programming ratio of 1000 ohm/V are to be retained.
The programming ratio of 1000 ohm/volt pertains to the pro-
gramming source as well. Consequently the coupling resistor
(R_i) must be 20 K ohms.

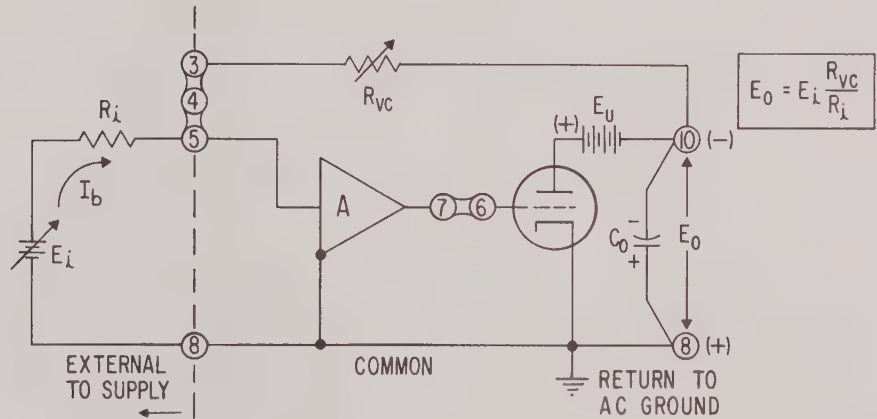


FIG. 3-6 VOLTAGE PROGRAMMING, OPERATIONAL NOTATION

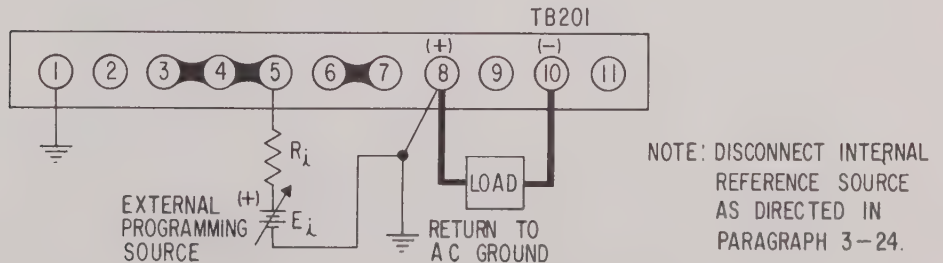


FIG. 3-7 CONNECTION FOR VOLTAGE PROGRAMMING

3-24 PROCEDURE (Refer to FIG. 3-5)

NOTE: Set "Voltage Control Calibrate" (R202A) to its maximum counter clockwise position. This disconnects the internal Reference Source from the circuit. R202A must be returned to its former position when resuming normal operation.

- a) Connect selected components as shown, observe polarities. Programming source must be isolated for at least the maximum output voltage of the power supply.
- b) Set the amplitude or voltage control of the programming source to the maximum selected programming voltage (20 V).
- c) Turn on the power supply to be programmed and the external programming source. Adjust the "Voltage Control" of the power supply to the selected maximum output voltage (1000 V).
- d) The output voltage will now track variations in the programming voltage at the proportion established, (1:50).

3-25 CONSTANT CURRENT OPERATION (EXTERNAL SENSING)

3-26 The ABC-HYBRID power supply, normally a constant voltage supply, can be readily converted to supply constant current. In the constant current operating mode, an external sensing resistor R_S and a current control resistor R_{CC} are connected to the voltage comparison bridge externally, while the internal voltage control is disconnected. (Refer to FIG. 3-8) The voltage drop across R_S (caused by the load current I_L) will now be regulated, thus providing constant current from the power supply. Characteristic of the constant current supply is its ability to change the output voltage automatically in order to maintain a constant current through a range of possible load resistances. This output voltage which the supply delivers under constant current conditions is referred to as "Compliance Voltage".

3-27 The current sensing resistor R_S is chosen to develop a ten volt drop at the maximum desired output current. It is calculated by dividing this current into ten volts. The value of R_S is not critical and can be the nearest standard resistance value available. Several facts should be kept in mind, however, when choosing R_S . A compromise must be made between a large and a small value. While a large value is desirable for good current regulation, it is less so in view of the power dissipated across it. It must be remembered that all the load current is flowing through R_S and the input to the regulator is connected to it. It is, therefore, vital that all extraneous changes across R_S , i.e., resistance change due to temperature, are kept to a minimum. A high quality, low T.C. (20 PPM) resistor, at least ten times the actual wattage needed, is therefore strongly recommended.

- 3-28 The current control resistor, R_{CC} , is chosen on the basis of the control ratio of the Kepco Comparison Bridge, and V_S the maximum voltage across R_S . If R_S was selected for 10 volt drop, then $V_S = 10$ volt and $R_C = V_S \times (\text{control ratio})$, or $R_C = 10 \text{ volt} \times \frac{1000 \text{ ohm}}{1 \text{ volt}} = 10000 \text{ ohms}$. A high quality, low T.C. (20 PPM) resistor is recommended for R_{CC} .

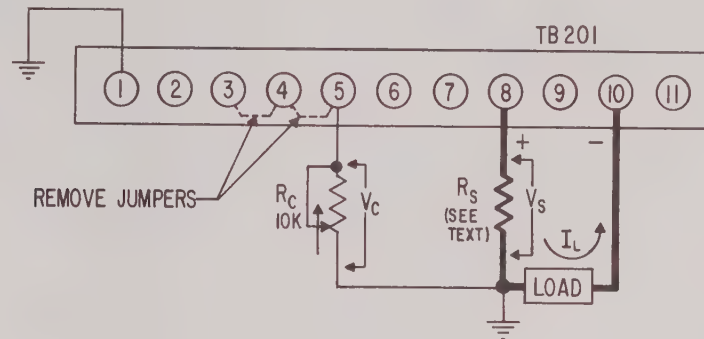


FIG. 3-8 CONNECTIONS FOR CONSTANT CURRENT OPERATION

3-29 PROCEDURE (FIXED OUTPUT CURRENT) (Refer to FIG. 3-8)

The set-up procedure for constant current operation is perhaps best shown by an example. A KEPCO Model ABC 1500 is to deliver a constant 5 mA into a load:

- Select R_S . Since we want a 10 volt drop across it and $I_L = 5 \text{ mA}$,

$$R_S = \frac{10 \text{ volt}}{0.005 \text{ A}} = 2000 \text{ ohm}$$
A wire-wound resistor, 2000 ohms, 1/2 W, 20 ppm will be satisfactory.
- The control resistor R_{CC} is found by:

$$R_{CC} = V_S \text{ times control ratio}$$

$$R_{CC} = 10 \text{ volt} \times 1000 \text{ ohm/volt} = 10000 \text{ ohm}$$
- The compliance voltage will vary from approximately zero to $E_O \text{ max.}$ as the load varies from maximum resistance to zero ohms.

3-30 PROCEDURE (VARIABLE OUTPUT CURRENT)

- 3-31 The load current I_L may be varied by adjusting the value of R_{CC} . The range of variable load current is from approximately 1 mA to the maximum rated output current of the power supply. This range can not be achieved continuously on units with higher output current capabilities because of the limitations imposed upon R_S . If the sample voltage (V_S) at the low end of the output current range

becomes too small, degradation of regulation and stability must be expected. If the sample voltage across R_S becomes too large at the high end of the output current range, power dissipation becomes very large and compliance is lost. It is therefore best to make a compromise in the selection of R_S and restrict the variable current range to approximately a 10:1 ratio. If this ratio is not sufficient, a new value of R_S should be calculated. (This will be the case for all ABC-HYBRID Models above 10 mA output current.)

3-33 The following is a sample calculation for an ABC 200M. A variable current is desired over the range of 20 to 100 mA. (1:5 ratio)

a) We select R_S to drop 10 volt at the maximum current (100 mA).

$$R_S = \frac{10 \text{ volt}}{0.1 \text{ A}} = 100 \text{ ohm.}$$

A wire wound resistor, 100 ohm, 10 W, with a T.C. of 20 PPM or better, will be sufficient.

b) The variable control resistor R_{CC} is calculated by finding its limits:

$$R_{CC} (\text{max.}) = V_S (\text{max.}) (\text{Control Ratio})$$

$$R_{CC} (\text{max.}) = 10 \text{ volt} (1000 \text{ ohms/volt}) = 10000 \text{ ohm}$$

$$R_{CC} (\text{min.}) = V_S (\text{min.}) (\text{control ratio})$$

$$\begin{aligned} \text{Where } V_S (\text{min.}) &= R_S (I_L \text{ Min.}); V_S (\text{min.}) = 100 \text{ ohm} (0.02\text{A}) \\ &= 2 \text{ volts} \end{aligned}$$

$$\text{Therefore } R_{CC} (\text{min.}) = 2 \text{ volts} (1000 \text{ ohms/volt}) = 2000 \text{ ohms.}$$

Consequently if R_{CC} is divided into two parts, a fixed 2000 ohm and a variable 8000 ohm, the current range from 20 to 100 mA can be continuously controlled.

3-33 PARALLEL OPERATION

3-34 The output of similar Model ABC-HYBRID power supplies can be connected in parallel across a common load to obtain higher load current within the same output voltage range. Rear barrier strip terminals are provided for access to the control grids of the series regulator tubes. The control grids are paralleled and driven from the amplifier of one supply only (Master-Supply). The amplifier of the other supply (Slave-Supply) will be disconnected.

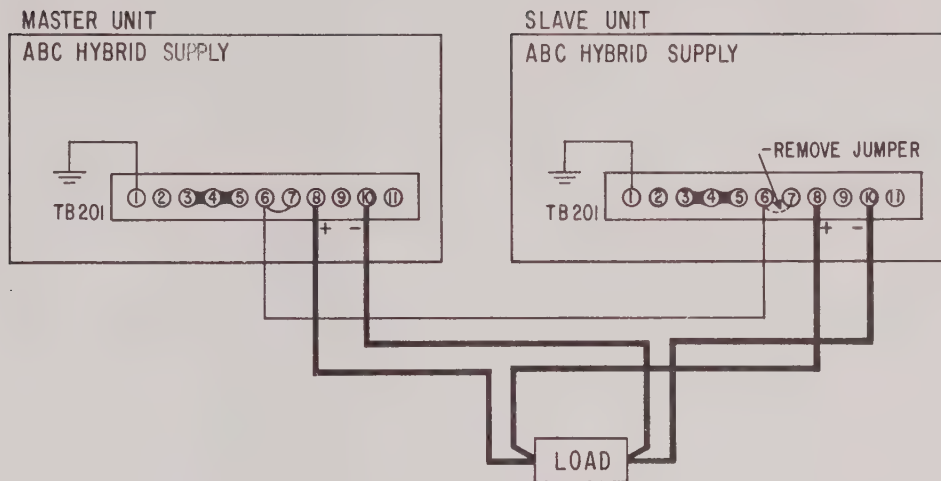


FIG. 3-9 CONNECTIONS FOR PARALLEL OPERATION

3-35 PROCEDURE (Refer to FIG. 3-9)

- a) Remove jumper link between terminals (6)-(7) on the rear barrier strip of the Slave-Supply.
- b) Connect power supplies as shown in FIG. 3-9. Equal lengths of load connecting wire should be used from both units to the load. Observe polarities.
- c) AC input power should be applied simultaneously to the power supplies. The output voltage is set with the panel voltage control on the Master-Supply.

SECTION IV - THEORY OF OPERATION

4-1 GENERAL

- 4-2 This section contains a description of the major circuitry of the power supplies in the Kepco ABC-HYBRID DESIGN GROUP. The purpose of the analysis is to provide the user with a functional understanding of the device and thus form a basis for successful operation and maintenance.
- 4-3 The simplified diagram (FIG. 4-1) and the main schematic (FIG. 5-5) should be used as a reference for the following circuit description.

4-4 CIRCUIT DESCRIPTION

- 4-5 AC INPUT CIRCUIT. AC power is introduced through a three-wire safety line cord, equipped with three-prong plug. The grounding prong is directly connected to the metal chassis and frame of the unit. When AC line switch (S1) is closed, T1 receives power immediately and DS1, the AC signal light, is energized. Fuse F1 protects the main transformer (T1) from overload.
- 4-6 MAIN DC SUPPLY. The main DC power is derived from a secondary winding on T1. The conventional full wave rectifier circuit (CR201 to CR204)* is working into a capacitor input filter (C1A), paralleled by input bleeder resistor R1.
- 4-7 PASS-ELEMENT CIRCUIT. The series regulator tube (V1) (two pass elements in series are used in Model ABC 2500) is connected in series with the positive output lead, so that the unregulated DC voltage from the rectifier circuit is divided between it and the output of the power supply. By properly "driving" the grid of the series regulator, its equivalent resistance (and thereby the voltage drop across it) is made to change in such a way as to maintain the output voltage constant. The grid drive necessary for this action is supplied by a driver transistor (Q204), which in turn is controlled by the output of the error-signal amplifier.
- 4-8 ERROR-SIGNAL AMPLIFIER. This four stage amplifier has the function of amplifying the signal derived from the comparison bridge to a level suitable to drive the series regulator tube. The input stage (Q201) is connected as a high impedance emitter follower which drives the following voltage amplifier stage (Q202). A second emitter follower (Q203) couples the signal to the driver stage (Q204), which supplies the

*Model ABC 200 uses only two rectifier diodes (CR201,202)

necessary grid signal to the series regulator tube. During an overload condition, the drive from Q204 to the series regulator tube is inhibited due to a positive signal created across R219 by excessive output current. The signal is transferred by CR209 to the base of Q204. The operating conditions of the driver stage are set by Q205, which is emitter follower-coupled to Q204. The bias conditions may be adjusted by R202B which is optimized on the basis of the maximum permissible short circuit current of the individual model.

4-9 COMPARISON BRIDGE CIRCUIT

The Comparison Bridge. This four-arm electrical bridge circuit is the regulating and controlling element in most Kepco Power Supplies. In the ABC-HYBRID Model, it consists of CR207 (E_r), R202A, R203 (R_r) and R4 (R_{vc}). The fourth arm is constituted by the output voltage (E_o). As shown in FIG. 4-1, the reference voltage (E_r) in series with R_r is compared continuously to the output voltage (E_o), in series with the voltage control resistor (R_{vc}). At balance, a constant current is flowing through the bridge, keeping the error-signal voltage at the bridge terminals A and A' at approximately zero volts. Any deviation from the set output voltage at balance will tend to change the bridge current in the sensing half and thereby produce an error-signal at the bridge terminals A and A'. This error-signal is then amplified and acts as a control signal for the series regulator element, changing the voltage drop across it in such a way as to compensate for the change in output voltage.

4-10 AUXILIARY SUPPLIES

- a) Model ABC 2500 only. The auxiliary voltages on the Model ABC 2500 are derived from several windings on T1. The screen supply for series regulator tube V2 is a conventional, half wave rectified and capacitor filtered supply, consisting of CR1 and C5 with R22 as the series resistor. The filament voltage for V2 is tapped-off from the same winding. The screen voltage for V1 is derived from a centertapped winding on T1, full-wave rectified by CR205 and CR211 and filtered by C3. R14 is the series resistor. This supply serves a dual purpose in supplying the necessary operating voltage for the error-signal amplifier via R2. The filament voltage for V1 comes from another, separate winding on T1. The collector voltage for driver stage Q204 is derived from a separate, half-wave rectified and capacitor filtered supply, (CR210, C4) and transferred via R215 to Q204.

- b) All Model ABC HYBRID, except ABC 2500. All auxiliary voltages (except filament) are derived from a single winding on T1. A full-wave rectifier circuit (CR205, CR211) works into a capacitive filter (C3) and delivers screen voltage for the series regulator tube (V1) via R14, as well as operating voltage for the error-sensing amplifier via R1. A separate half wave rectifier (CR210), its output filtered by C4, provides the collector voltage for the driver (Q204). Filament voltage is taken from a separate winding on T1.
- c) Models ABC 200 and ABC 425 have an auxiliary filament winding on T1 which is brought out at the rear barrier strip (TB201) on terminals (2) and (11).

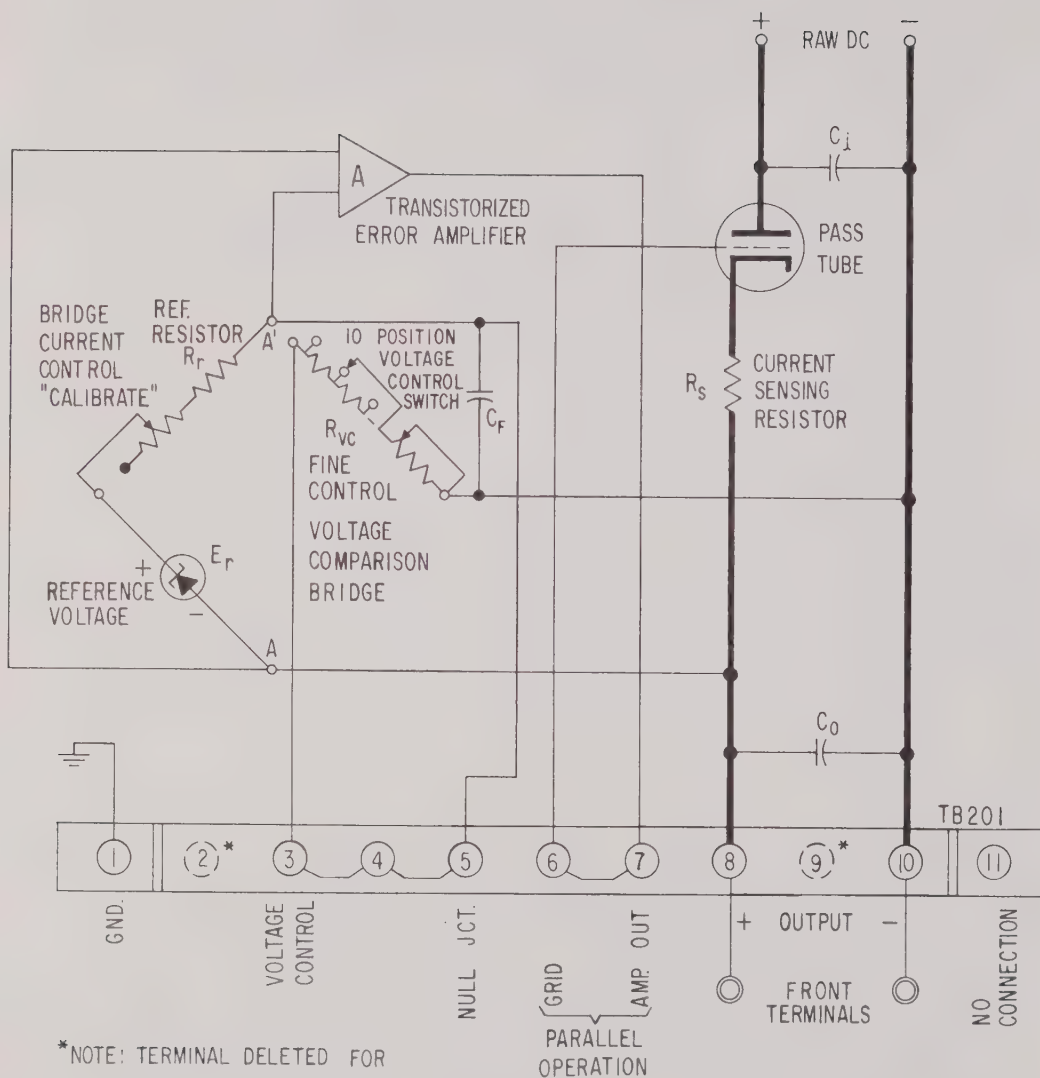


FIG. 4-1 SIMPLIFIED DIAGRAM AND CONNECTION GUIDE FOR MODELS ABC 1000, ABC 1500 AND ABC 2500

5-1 GENERAL

- 5-2 Conservative rating of all components, and avoidance of congested layout in the ABC supplies keep maintenance problems to a minimum. If component failure does take place however, easily accessible components in conjunction with the information contained in this manual, will enable the user to keep the down time to a minimum.

5-3 INTERNAL ADJUSTMENTS (Refer to FIG. 2-1 and FIG. 2-2)

- a) VOLTAGE CONTROL CALIBRATION. The voltage control calibrating resistor (R202A) adjusts the bridge current (I_b) in the comparison bridge. For the procedure of this adjustment refer to Paragraph 3-13. For noncritical applications, the front-panel "Voltage Adjust" control may be calibrated by setting it to its maximum clockwise position and adjust R202A to the maximum rated output voltage of the supply.
- b) MAXIMUM CURRENT ADJUSTMENT. The "Maximum Current Adjust" control (R202B) sets the maximum permissible short circuit current (approximately 150% of the rated output current of the individual model).

PROCEDURE:

- 1) Set front panel "Short Circuit Current Adjust" control (if unit is so equipped) to its maximum clockwise position. Remove unit from its case and connect to power line. USE EXTREME CAUTION in operating the exposed unit. Use only insulated screw driver for adjustment.
- 2) Load supply to maximum rated output current. Observe output ripple across the load with a suitable oscilloscope.
- 3) The supply ripple should be in the order of 1 to 2 mV p-p. If it is substantially higher turn R202B clockwise until ripple goes down to specified values. If the ripple appears normal, adjust R202B counter clockwise until the ripple increases sharply, then back off slightly on the control until ripple appears normal once again.
- 4) Short circuit the output of the supply and note the short circuit current on the panel meter. (If unit is an unmetered model, connect a suitable ammeter in series with the short circuit across the output terminals.) The short circuit current should be approximately 50% higher than the maximum output current of the power supply. This concludes the adjustment of R202B. Re-install unit in its case.

5-4 TROUBLE SHOOTING

5-5 Servicing beyond simple part replacements should be attempted only by personnel thoroughly familiar with solid state component techniques and with experience in closed loop circuitry. Trouble-shooting charts showing resistance and voltage readings are of limited usefulness with feedback amplifiers. We have therefore not included them here. Presented instead is a circuit description, parts location diagrams, a simplified schematic of the feedback circuit and the main schematic with the more important voltage readings. It has been our experience that with these aids, a skilled technician will in most cases be able to service the supply. In more difficult cases, the nearest Kepco Field Engineering Office, or the Kepco Repair Department at the factory, is always available for prompt service.

5-6 POWER SUPPLY MEASUREMENTS (Refer to FIG. 5-1 and FIG. 5-2)

5-7 Measurement of the significant parameters of a power supply is a requirement for incoming inspection, periodic maintenance, or after component replacement. Since these measurements require special techniques to insure correct results, suggestions for their performance are given below:

a) Required Instrumentation:

- 1) Constant AC supply voltage with provisions for "stepping" or varying the voltage over the specified range (105-125V); a variable autotransformer is generally adequate. It must be rated to deliver the input current of the unit under test.
- 2) Resistive load, variable, with on and off switch and capable of dissipating the full output power of the unit under test.
- 3) DC Voltage Monitor, Differential or Digital Voltmeter.
- 4) Current sensing resistor, for current regulation measurements, four terminal device.
- 5) AC ripple monitor, sensitivity better than 1 mV. Ballantine Model 302C, or H.P. Model 400H.
- 6) Optional: Oscilloscope, vertical sensitivity better than 1 mV/cm.

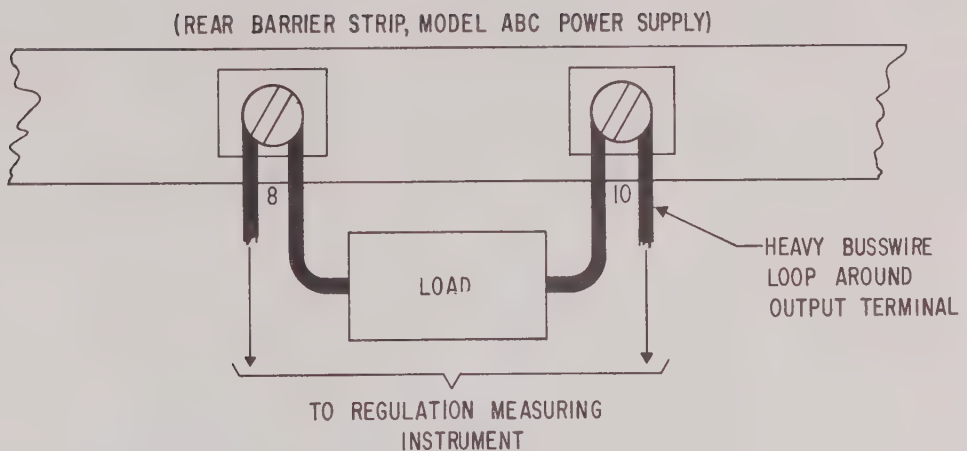


FIG. 5-1 APPROXIMATION OF A FOUR TERMINAL NETWORK

- b) The Four Terminal Network is an essential device for precise measurement of regulation. It can be approximated by the method shown in FIG. 5-1, FIG. 5-2 below shows the proper location of instrument leads when measuring regulation. The principle governing this method of measurement is simply not to measure any voltage drops due to load current flow. This can only be avoided by measuring regulation either directly at the sensing leads or by the use of the four-terminal network.

- c) Voltage Regulation is defined as the amount of output voltage change resulting from a specified change of line voltage or from a change in load resistance. It can be expressed as an absolute change ΔE_O or as a percentage in reference to the total output voltage E_O :

$$\% \text{ Voltage Regulation} = \frac{\Delta E_O}{E_O} (100\%)$$

- d) Current Regulation is defined as the amount of output current change resulting from a specified change in line voltage or from a change in load resistance. It can be expressed as an absolute change ΔI_O , or as a percentage in reference to the total output current I_O :

$$\% \text{ Current Regulation} = \frac{\Delta I_O}{I_O} (100\%)$$

- e) Ripple. An oscilloscope of suitable sensitivity or a true RMS indicating meter may be used to measure the ripple at the output of the power supply. Suitable DC blocking must be provided. A 0.1 mfd capacitor of sufficient working-voltage is generally adequate. The peak-to-peak to RMS ratio for a pure sine wave is approximately equal to 2.83:1. For broken waveform such as from a series regulator, 3:1 is a good approximation. Ripple measurements across current sensing resistors must be converted to current by the use of Ohm's law.

NOTE: Great care is required if valid measurements of current ripple are desired. The use of completely shielded sensing resistors and load cables may be necessary to get accurate readings.

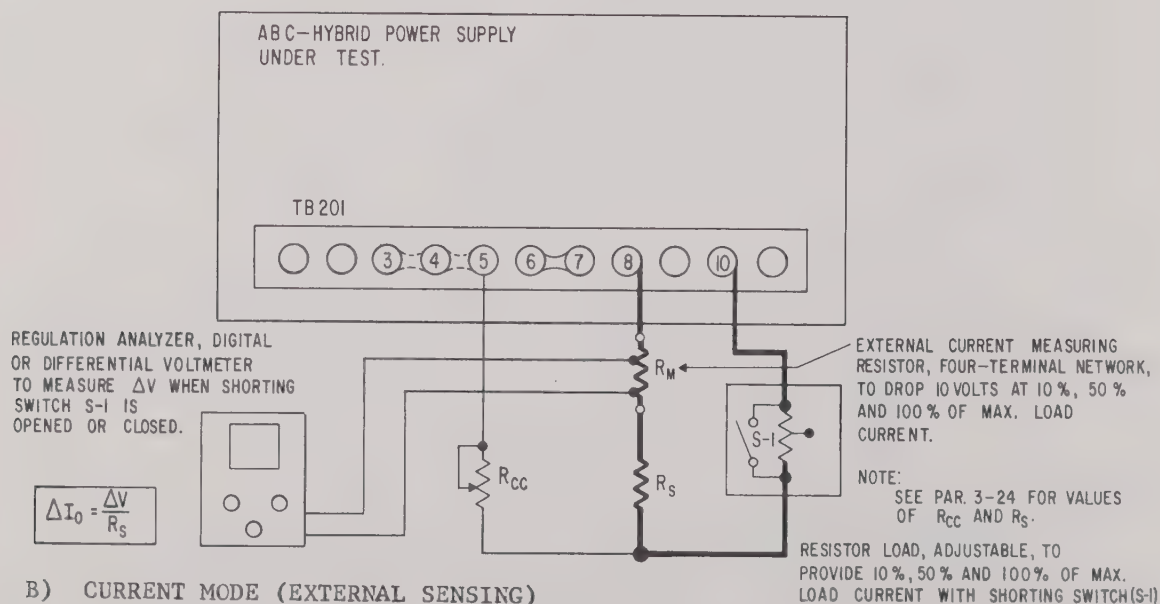
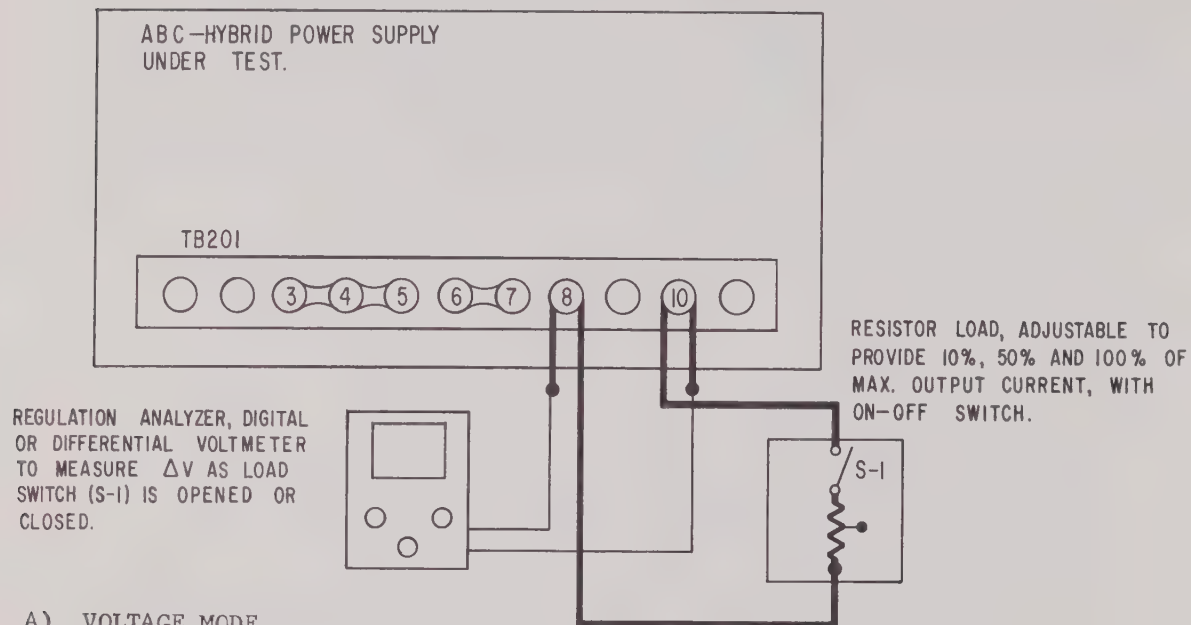


FIG. 5-2 REGULATION MEASUREMENT ON ABC-HYBRID POWER SUPPLIES

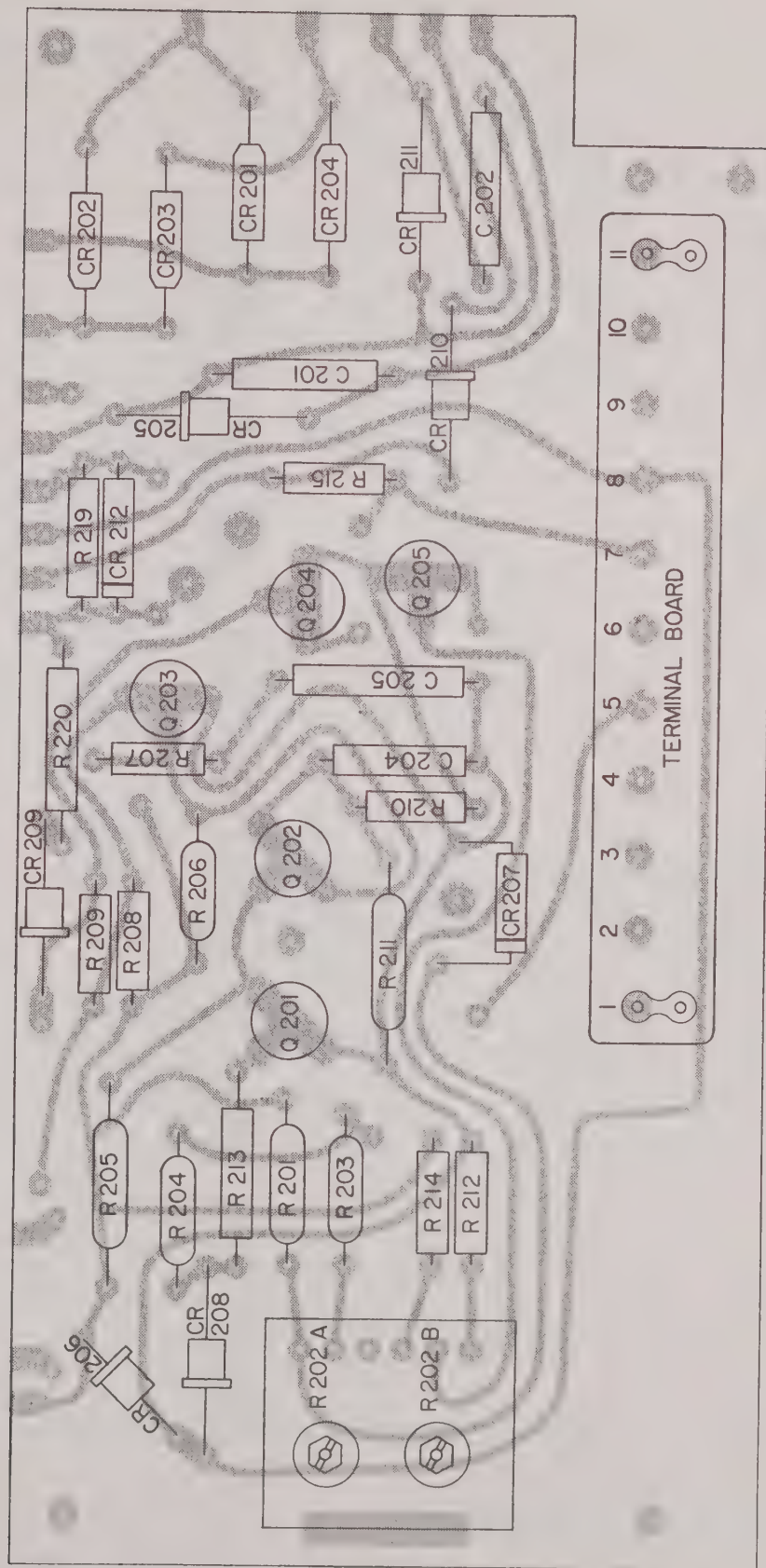
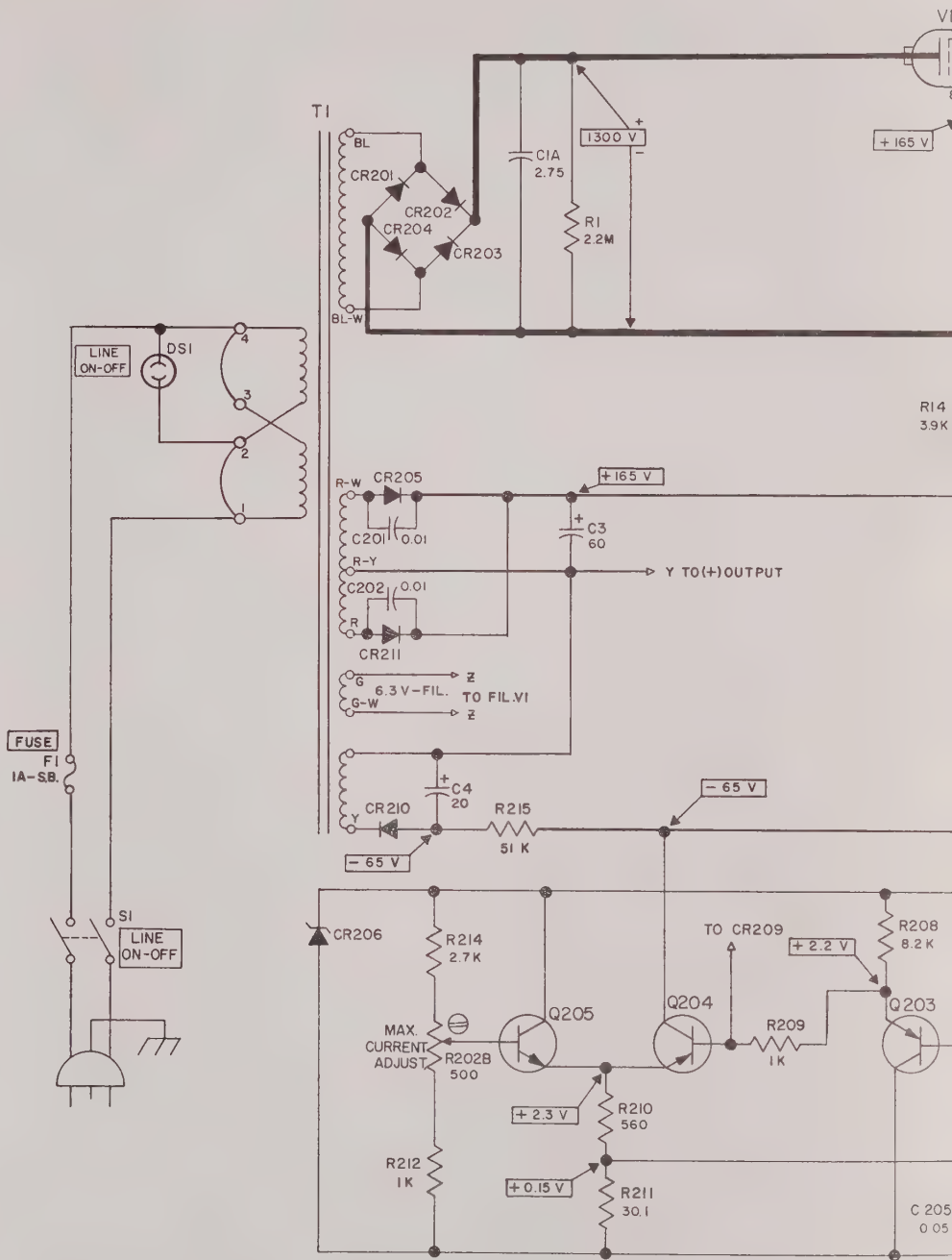
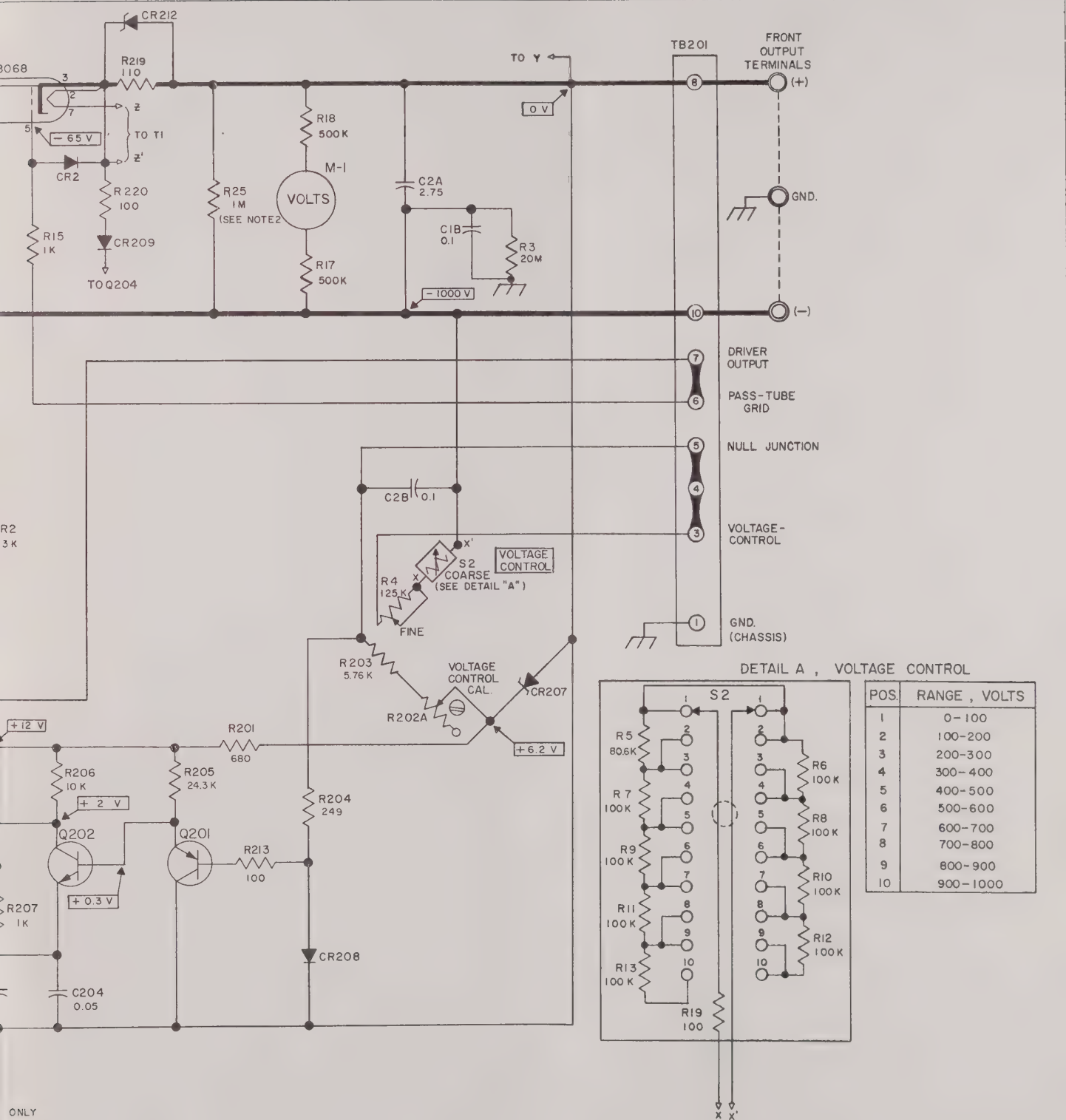


FIG. 5-3 COMPONENT LOCATION, PCB#1

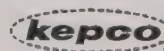


NOTES :

1. ALL RESISTOR VALUES ARE IN OHMS, K=1000.
ALL CAPACITOR VALUES ARE IN MICROFARADS, K=1000.
2. M1, R17,R18 ON METERED MODELS ONLY. R25 ON UNMETERED MODELS.
3. ITEMS WITH REFERENCE DESIGNATIONS 200-299 ARE MOUNTED ON PRINTED CIRCUIT BOARD.
4. VOLTAGES ARE DC, TYPICAL VALUE. MEASURED TO (+) DC OUTPUT TERMINALS WITH 20 K.OHMS/VOLT METER; AC LINE 115V; OUTPUT SET TO MAXIMUM.
5. TRANSFORMER CONNECTIONS SHOWN FOR 115 V AC OPERATION.



ONLY
INAL
VDC, NO LOAD.



Data subject to change without notice
PATENT NOTICE: Applicable Patent Nos.
will be supplied on request.



REPLACEMENT PARTS LIST

POWER SUPPLY MODEL ABC 1000M

Code 6-2667

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C1a,1b,	2	Capacitor,Electrolytic,Can	General Electric	117-0379
2a,2b		0.1 μ F - 2.75 μ F, 1.8 KV	28F1017	
C3	1	Capacitor,Electrolytic,Pigtail	Industrial Cond.	117-0102
		60 μ F, 250 V	20B296	
C4	1	Capacitor,Electrolytic,Pigtail	General Electric	117-0145
		20 μ F, 150 V	43F2271AA2	
CR2	1	Rectifier,Silicon,Pigtail	Semicon Inc.	124-0133
			SM-110	
DS1	1	Pilot Light	Industrial Devices	152-0070
			1040A75	
F1	1	Fuse,Slo Blo	Bussman	141-0047
		1 A, 250 V	MDL-1	
*M1	1	Meter	General Electric	135-0242
		1 KV/1 MA	DW91/50-152111	
R1	1	Resistor,Fixed,Film	International Resis.	115-1228
		2.2 Megohm, 2 W, 20%	MVX-2	
R2	1	Resistor,Fixed,Power,Strip	Hardwick Hindle	115-1337
		3 K ohm, 10 W, 5%	2BRS-56	
R3	1	Resistor,Fixed,Film	International Resis.	115-1229
		20 Megohm, 2 W, 20%	MVX-2	
R4	1	Resistor,Variable,10-Turn	IRC	115-1294
		125 K ohm, 8 W, 3%	HD-150	
R5	1	Resistor,Fixed,Precision,M.F.	IRC	115-2109
		80.6 K ohm, 1 W, 1%	CES Type	
R6,7,8,	8	Resistor,Fixed,Precision,M.F.	IRC	115-2004
		100 K ohm, 1 W, 1%	CES Type	
R14	1	Resistor,Fixed,Molded	Allen Bradley	115-0921
		3.9 K ohm, 1/2 W, 10%	EB3921	
R15	1	Resistor,Fixed,Molded	Allen Bradley	115-0547
		1 K ohm, 1/2 W, 10%	EB1021	
*R17,18	2	Resistor,Fixed,Precision	Wilrite	115-0230
		500 K ohm, 2 W, 0.5%	CMC-2	
R19	1	Resistor,Fixed,Precision,M.F.	IRC	115-1846
		100 ohm, 1 W, 1%	CES Type	
**R25	1	Resistor,Fixed,Carbon Film	Kidco	115-1343
		1 Megohm, 2 W, 5%	C2C	
S1	1	Switch,Toggle,DPST	Carling Electric	127-0010
		15 A, 125 V	2GK-53	

*Metered Models Only

**Un-metered Models Only

REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS, REPRESENTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.



REPLACEMENT PARTS LIST

POWER SUPPLY MODEL ABC 1000M

Code 6-2667

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
S2	1	Switch, Rotary 2 Pole, 10 Position	Centralab BF00824	127-0168
T1	1	Transformer	Kepco Magnetics 100-1352	100-1352
V1	1	Vacuum Tube	General Electric 8068	126-0096

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REPLACEMENT PARTS LIST

CONTROL BOARD ASSEMBLY MODEL ABC 1000(M)

Code 6-2667

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C201, 202	2	Capacitor, Fixed, Mylar 0.01 μ F, 400 V, 20%	Sprague 192P10304	117-0361
C204	1	Capacitor, Mylar 0.05 μ F, 200 V, 20%	TRW Type X663F	117-0315
C205	1	Capacitor, Mylar, Pigtail 0.05 μ F, 200 V, 10%	TRW X663F	117-0362
CR201, 202, 203, 204	4	Rectifier, Silicon, Pigtail	Solitron Devices HV28A	124-0137
CR205, 208, 210, 211	4	Rectifier, Silicon, Pigtail	Semicon Inc. SM-140	124-0028
CR206	1	Zener Diode	Hoffman HZ(1)R12	121-0012
CR207	1	Zener Diode	International Rect. 1N821	121-0041
CR209	1	Rectifier, Silicon, Pigtail	Semicon Inc. SM-110	124-0133
CR212	1	Zener Diode	Hoffman 1N1767	121-0042
Q201, 203	2	Transistor, Silicon, PNP	Hughes 2N1131A	119-0055
Q202, 205	2	Transistor, Silicon, NPN	General Electric 2N336A	119-0056
Q204	1	Transistor, Silicon, PNP	RCA 2N4036	119-0074
R201	1	Resistor, Fixed, WW 680 ohm, 1 W, 3%	Tepro TS1W	115-1207
R202a, 202b	1	Resistor, Variable, Mult. Comp. 1.5 K ohm/500 ohm, 1/4 W, 30%	C. T. S. X152	115-1208
R203	1	Resistor, Fixed, Precision, M. F. 5.76 K ohm, 1 W, 1%	IRC CES Type	115-1893
R204	1	Resistor, Fixed, Precision, M. F. 249 ohm, 1 W, 1%	IRC CES Type	115-2105
R205	1	Resistor, Fixed, Precision, M. F. 24.3 K ohm, 1 W, 1%	IRC CES Type	115-1806
R206	1	Resistor, Fixed, Precision, M. F. 10 K ohm, 1 W, 1%	IRC CES Type	115-1821
R207	1	Resistor, Fixed, Molded 1 K ohm, 1/2 W, 5%	Allen Bradley EB1035	115-0340
R208	1	Resistor, Fixed, Molded 8.2 K ohm, 1/2 W, 10%	Allen Bradley EB8221	115-1169
R209, 212	2	Resistor, Fixed, Molded 1 K ohm, 1/2 W, 10%	Allen Bradley EB1021	115-0547

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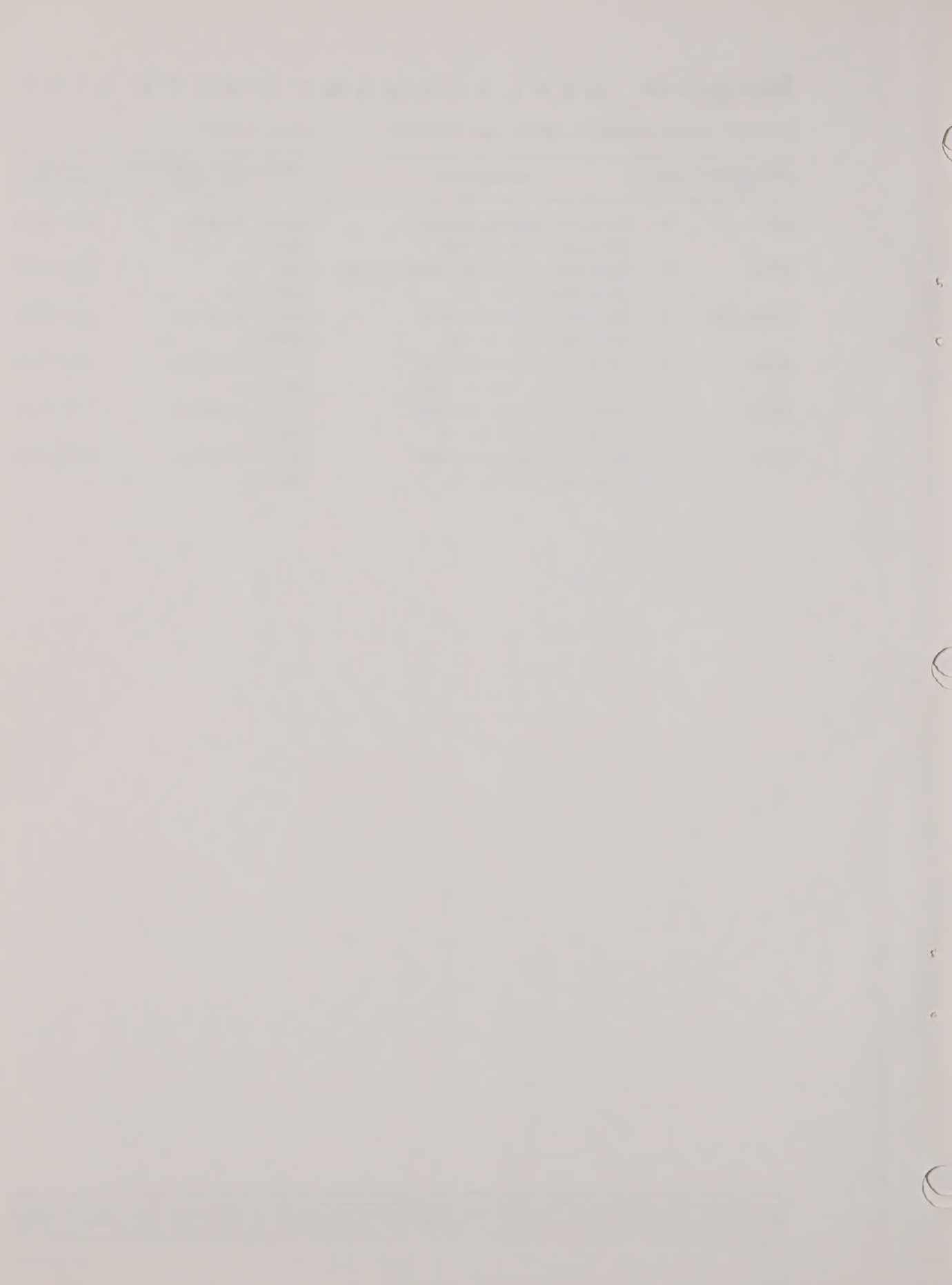
REPLACEMENT PARTS LIST

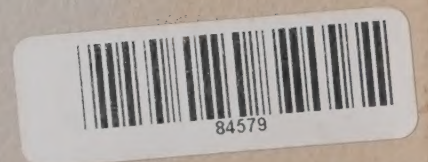
CONTROL BOARD ASSEMBLY MODEL ABC 1000(M)

Code 6-2667

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
R210	1	Resistor, Fixed, Molded 560 ohm, 1/2 W, 10%	Allen Bradley EB5611	115-0451
R211	1	Resistor, Fixed, Precision, M. F. 30.1 ohm, 1 W, 1%	IRC CES Type	115-2028
R213, 220	2	Resistor, Fixed, Molded 100 ohm, 1/2 W, 5%	Allen Bradley EB1015	115-0341
R214	1	Resistor, Fixed, Molded 2.7 K ohm, 1/2 W, 10%	Allen Bradley EB2731	115-0560
R215	1	Resistor, Fixed, Molded 51 K ohm, 1/2 W, 5%	Allen Bradley EB5135	115-0939
R219	1	Resistor, Fixed, Molded 110 ohm, 1/2 W, 5%	Allen Bradley EB1115	115-0884

REPLACEMENT PARTS MAY BE ORDERED FROM KEPKO, INC. ORDERS SHOULD INCLUDE KEPKO PART NUMBER AND DESCRIPTION.
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